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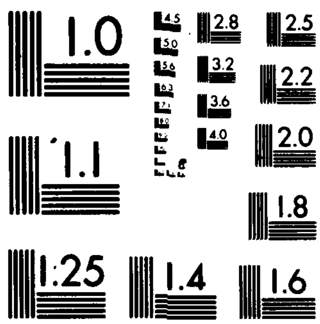

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AIR WEATHER SERVICE

EAST COAST FOG:
A CASE STUDY

Thomas C. Wann, Major, USAF

November 1981

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Fog formation
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This case study covers a 48-hour period, 27-29 December 1980, of an extensive East Coast fog situation. An abnormal cold air mass over the eastern seaboard was confronted with a warm, moist onshore flow. The brisk onshore flow was a result of a strong pressure gradient which developed between an intensifying high and deepening low. The study emphasizes the need for a local analysis program which will detect onshore flow and possible extensive fog formation.

EAST COAST FOG: A CASE STUDY

1. Introduction.

Widespread, dense fog and low ceilings engulfed the eastern U.S. seaboard from Cape Hatteras to Cape Cod on 28 Dec 80 and persisted for 36 hours. The extent and duration of this fog caught many forecasters by surprise. Although a classic fog situation, the actual cause was misunderstood by many. The general synoptic condition leading up to this period was extremely cold air over the eastern third of the U.S., extending over most of Florida. Record-breaking low temperatures were set at many locations, and a rare, early snow was recorded in Charleston, South Carolina. A persistent upper-level trough cut off over northern Florida 12 hours prior to the onset of the heavy fog, and the polar jet stream shifted north across Canada. Most East Coast forecasters were concentrating on the fate of the cut-off cold low and basing their forecasts on its forecast movement. This preoccupation with the upper-level low may have distracted many forecasters from what was going on with an anticyclone over the North Atlantic. It is the intensification of this anticyclone along with the cut-off low that becomes a major factor in the cause of widespread fog. This case study shows why this was such an impressive fog producer - a textbook classic. The LFM handled the system fairly well and will not be an object of this study.

2. Discussion.

Let's first look at the general synoptic patterns at the surface, 850-, 700-, 500-, and 300-mb for 27/12Z to 29/12Z December 1980.

a. 27/12Z. On 27/12Z there is a 1039-mb surface high center over Ontario and a polar frontal system in the north central Atlantic, extending to a low off the coast of Georgia (Figure 1). A major winter storm is developing over the southern Canadian Rockies. The cold air over the eastern third of the U.S. is very evident at 850 mb (Figure 2). At the 700-mb level, there is a cut-off low over northern Florida, with warm air advection over the northeast U.S. and the northern Plains (Figure 3). The low over Florida at 500 mb has a -25°C cold center with very little thermal advection (Figure 4). The wind maximum of 125 kt at 300 mb on the back side of the cut-off low is greater than that on the front side and suggests retrogression (Figure 5). As at 500 mb, there is little thermal advection to suggest filling, deepening, or movement; the main polar jet appears split, with a northern branch over central Canada/ Hudson Bay and a southern branch going southeast over the Mississippi valley.

b. 28/00Z. By 28/00Z the surface high over Ontario moves east into northern Maine and increases to a 1043-mb center. The low off the coast of Georgia deepens from a 1012-mb to 1010 center (Figure 6). The winds over the Atlantic just off the New Jersey coast increase from 10 to 15 knots. Widespread precipitation extends from rain in Georgia to snow and freezing rain in Virginia. The winter storm moves east out of the Canadian Rockies into the Plains. At 850 mb the low off the Georgia coast has closed height contours and deepens 30 meters while the ridge over New England rises 30 meters (Figure 7). The pressure gradient off the central East Coast doubles. Moderate warming is evident throughout the eastern third of the U.S. Similar conditions are seen at 700 mb (Figure 8) and 500 mb (Figure 9). At 300 mb the main polar jet is well established over Hudson Bay with a split down the Mississippi valley (Figure 10). The low is now cut off, but there is warm air advection into the closed low which suggests it may begin to fill.

c. 28/12Z. The surface low off Georgia deepens 5 more mb since 28/00Z (Figure 11). The NMC analysis forces an associated occluded front into this low, but post analysis using satellite data and upper air stacking shows a simple wave on the front is more fitting, remembering that the polar jet is way north in Canada. In fact, throughout this 2-day period there is no dynamic support for an occlusion off the east coast of the U.S. By this time snow has spread into Massachusetts, and there is extensive fog throughout New Jersey and heavy rain in the Carolinas. Satellite data shows the low center has remained quasi-stationary for the past 24 hours. Meanwhile the high center over Maine moves south five degrees, further tightening the gradient between the high and the cut-off low. At 850 mb, 4 to 7C° of warming has occurred in the past 12 hours over the southeast U.S., and the gradient off the central East Coast tightens as the high rises and the low deepens, supporting 35-kt winds from the east-southeast (Figure 12). The low associated with the storm moving across Canada is now over Hudson Bay, with a fairly tight gradient and 70-kt winds. At 700 mb the ridge strengthens over the north central U.S. coast and the closed low deepens slightly (Figure 13). The 500-mb temperature over Tennessee increases 6C° in 12 hours, suggesting strong, warm air advection toward the southeast into the low (Figure 14). At 300 mb, warming is evident throughout the southeast U.S. (Figure 15). The polar jet is well established over Hudson Bay, and the split down the Mississippi valley appears to have broken off, with increased ridging over the Great Lakes.

d. 29/00Z. The surface high centered over Maine begins to move rapidly to the east and decreases in central pressure (Figure 16). The closed low moves east, but the gradient between the high and low

remains about the same, with continuing moderate onshore flow. By this time the warm, moist flow from off the eastern seaboard has penetrated several hundred miles inland. Dew points in upstate New York and western Pennsylvania that were around 10°F twelve hours earlier are now in the 30's. Heavy fog extends from the upper part of New England down to North Carolina. At the 850 and 700-mb levels, little change is evident (Figures 17 and 18). Temperatures increase five degrees over Georgia in 12 hours at 500 mb (Figure 19). Winds over the Ohio valley at 300 mb show the overall trough and cut-off low moving slightly to the east (Figure 20).

e. 29/12Z. On the morning of the 29th all of New England and the East Coast down to South Carolina is covered with dense fog (Figure 21). The closed low has moved slightly northeast along the coast line. The high moves further into the North Atlantic, and the gradient between it and the low continues to weaken. At 850 mb, the 2-day change over the southeast U.S. is dramatic (Figure 22) - from a very cold trough at 27/12Z to a modifying cut-off cold low at 29/12Z, with a temperature increase of 12C° over these 48 hours. At 700-mb, 500-mb, and 300-mb (Figures 23, 24, and 25), there is strong, cold air advection over the Midwest toward the southeast U.S. associated with the next storm system.

f. Time Cross-Section. To see why there was widespread fog, it helps to understand what is happening to the air mass over the eastern seaboard. The vertical, time cross-section of Wallops Island (Figure 26) shows the warm air advection very graphically in the lower levels. Wallops Island was chosen since it is a key station that East Coast forecasters should watch. At 27/12Z the 1000-mb wind shifts to the northeast at 20 kt and by 28/00Z the 850-mb wind has an easterly component and the 850-mb temperature increased 7C° in 24 hours. Another clue to warm air advection is the wind veering with height. At 28/00Z it is very obvious that significant,warm, moist air is moving over the central East Coast from the east.

g. Factors related to fog formation. Prior to 27 Dec 80 the entire eastern third of the country had been under a very cold, record-breaking air mass, and the surface ground temperatures were well below freezing. This is a perfect setting for low fog and stratus conditions. Warm, moist air moving over a relatively cold surface, air with dew points near 50°F flowing over land with surface temperatures below freezing, is a textbook classic. Evidence that the high pressure was intensifying and that the low off Georgia was not moving north is the positive 24-hour pressure changes for stations in New Jersey, Virginia, and surrounding areas. Soundings for Atlantic City, NJ, Washington, DC, and Wallops Island show the wind easterly in the lower levels by 27/12Z, veering with height. With a situation like this, the forecast obviously is for fog with near-minimum conditions to last until the low level winds shift to a westerly direction. This occurred when the ridge off New England moved rapidly to the east after 29/12Z and the ensuing trough approached from the west.

3. Conclusion.

The lesson learned from this forecast review is that anytime abnormally cold air sets up over the eastern seaboard, cooling the land well below the East Coast and Gulf Stream sea surface temperatures, an east, onshore wind from the Atlantic will bring widespread fog conditions. In this case the closed low off the southeast U.S. coast distracted the forecasters from this basic forecast consideration. The 24-hour pressure rises over New Jersey should have given a clue that the low wasn't moving north and that the ridge was building. An East Coast station's local analysis program should be geared to identify an increased gradient off the East Coast and warm, moist air advection.

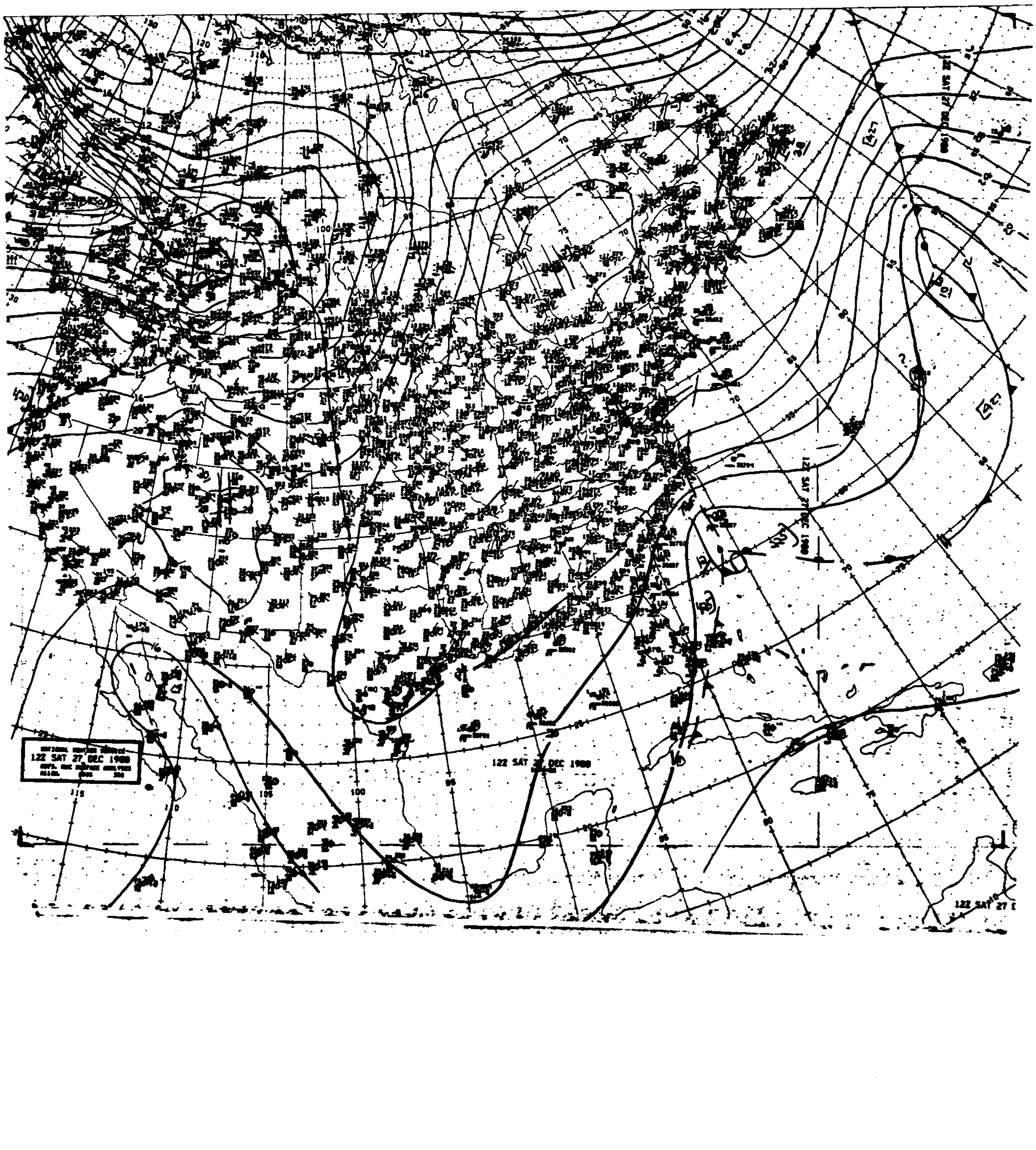


Figure 1. 27/12Z Surface Analysis.

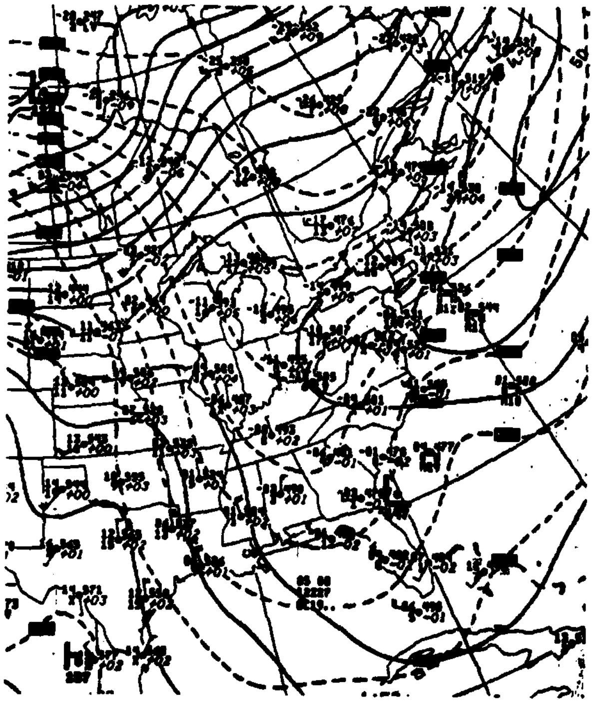


Figure 2. 27/12Z 850-mb Analysis.

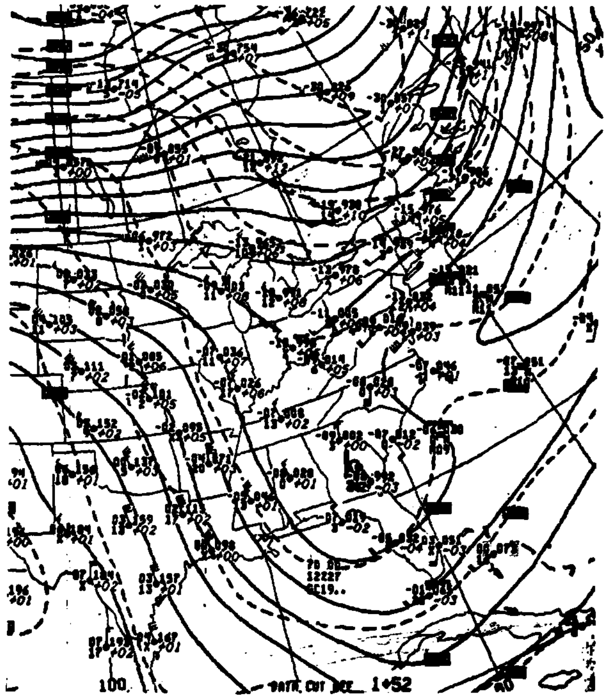
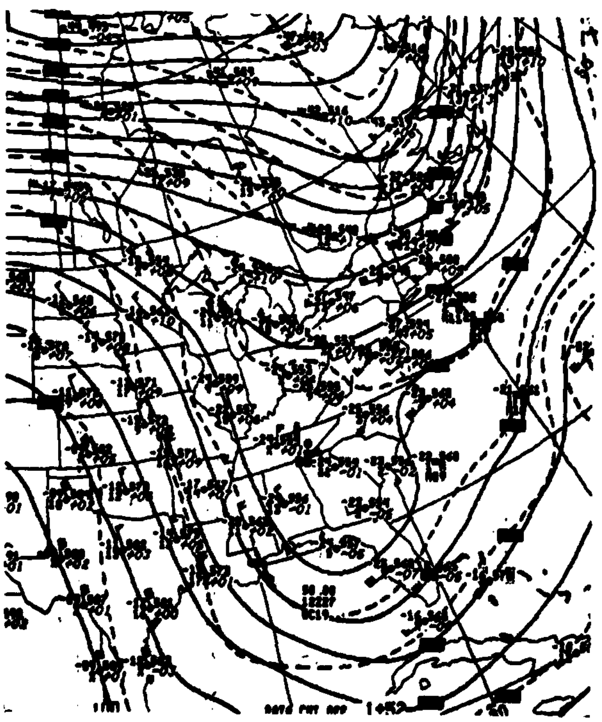


Figure 3. 27/12Z 700-mb Analysis.



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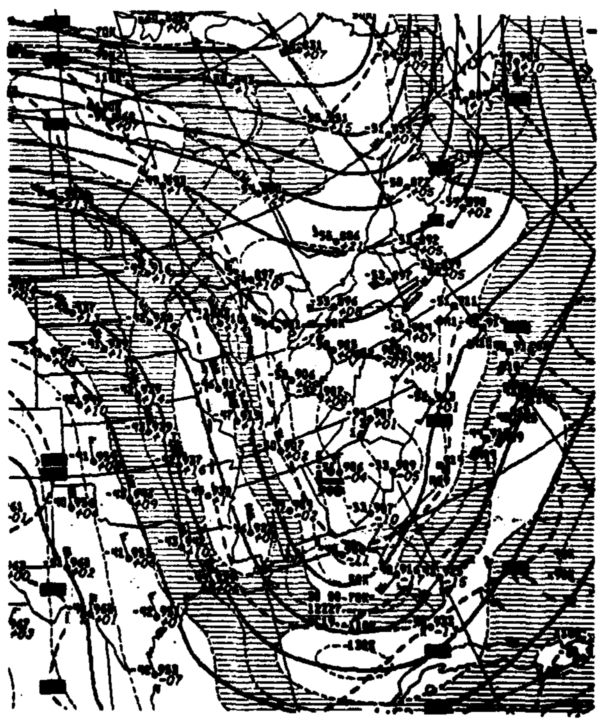

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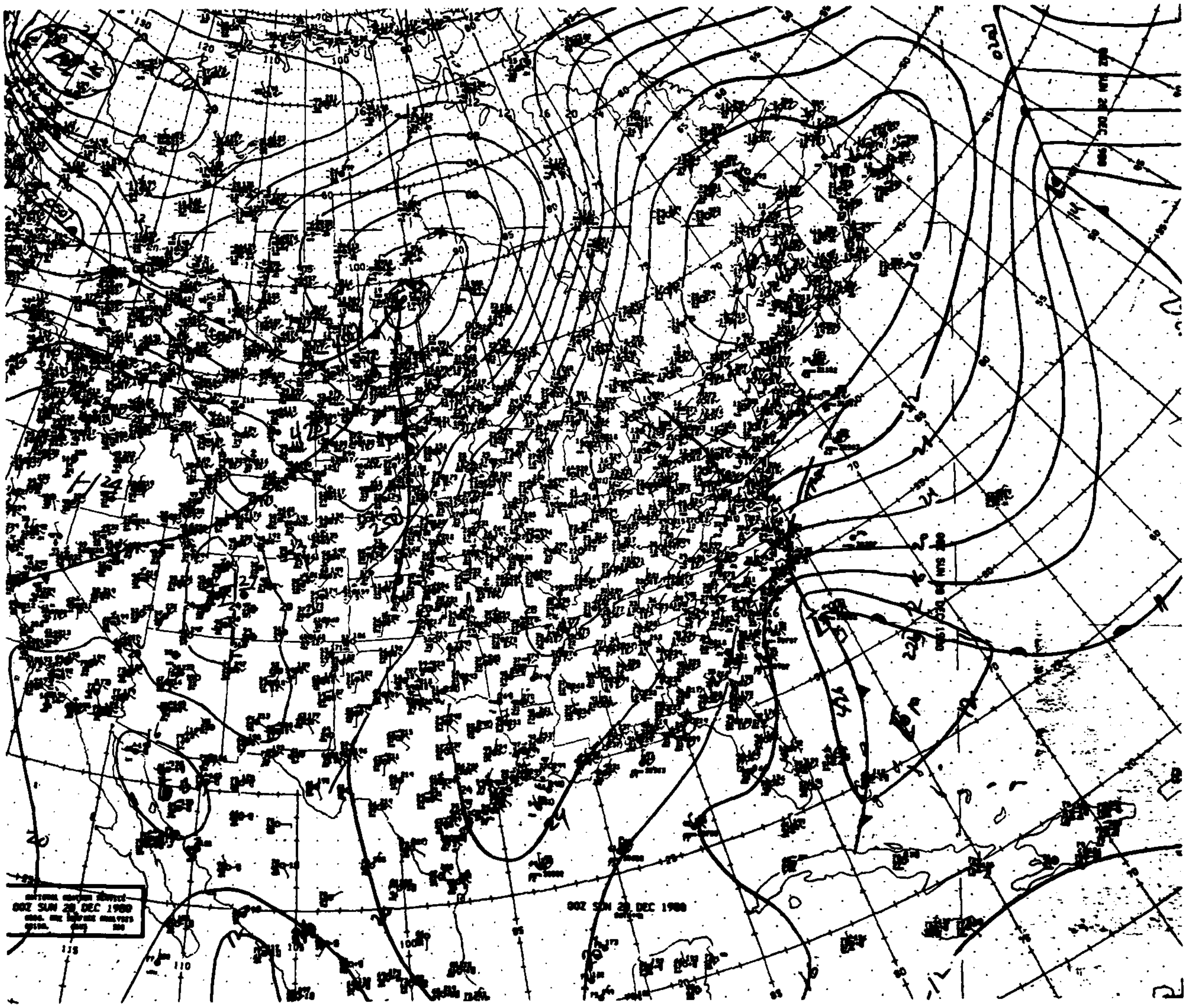
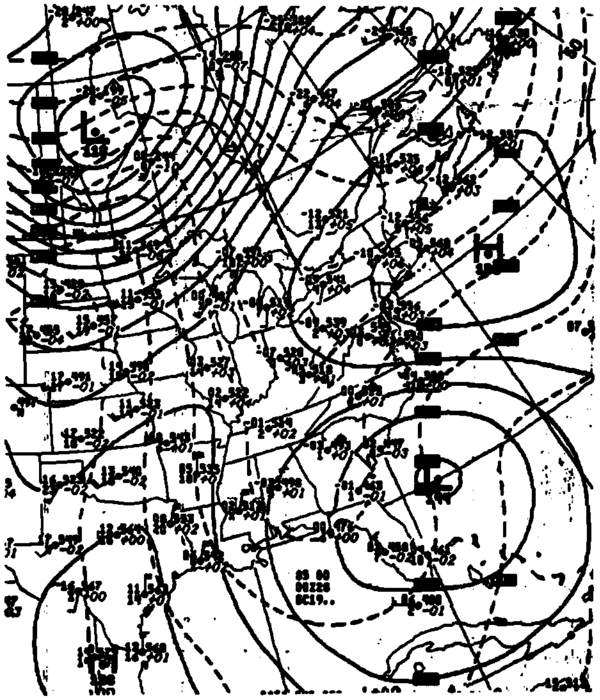


Figure 6. 28/00Z Surface Analysis.



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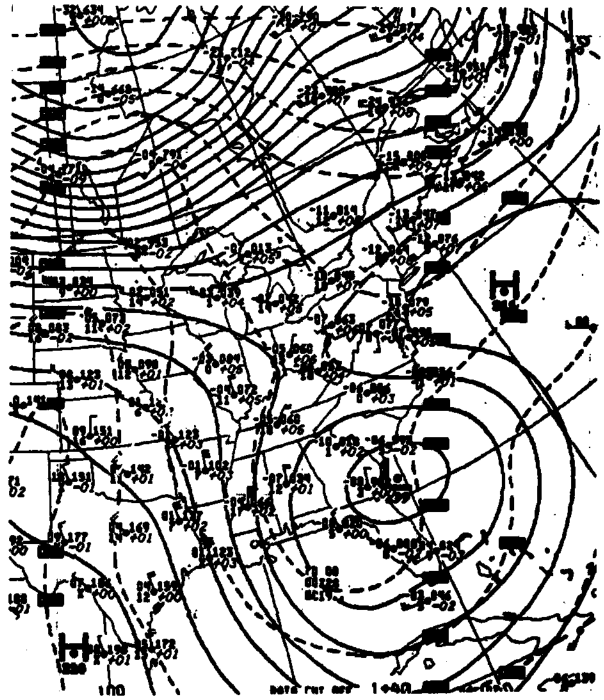

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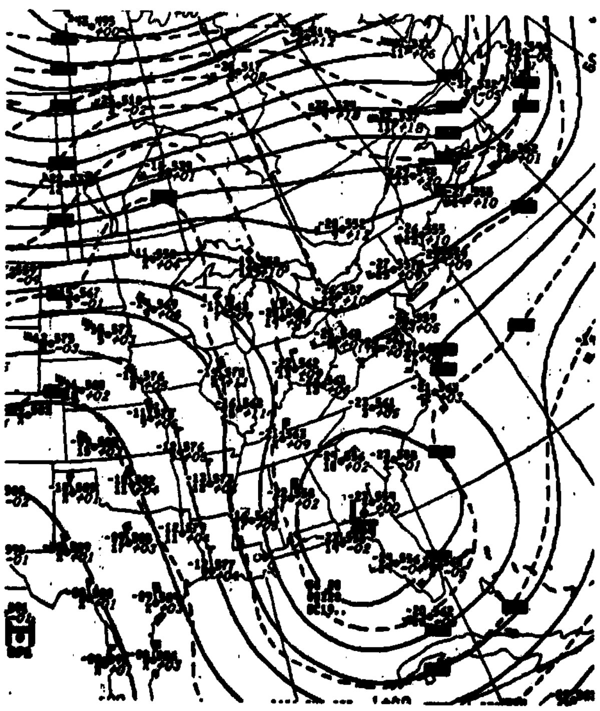

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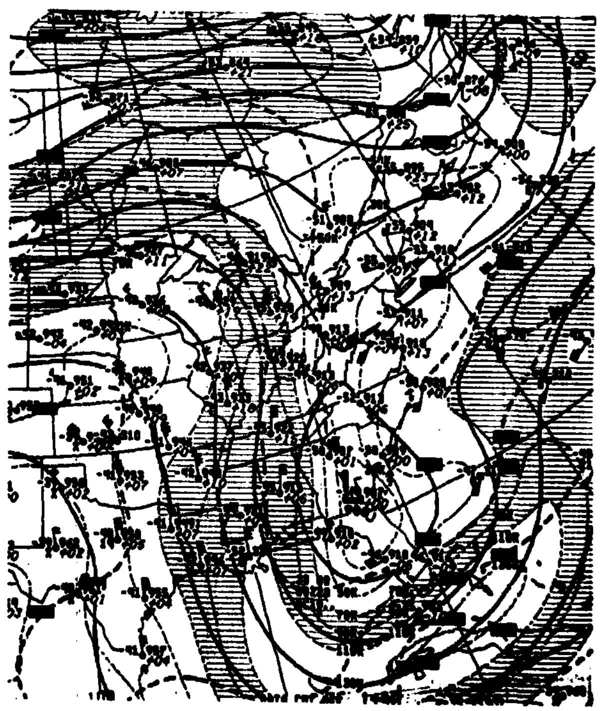

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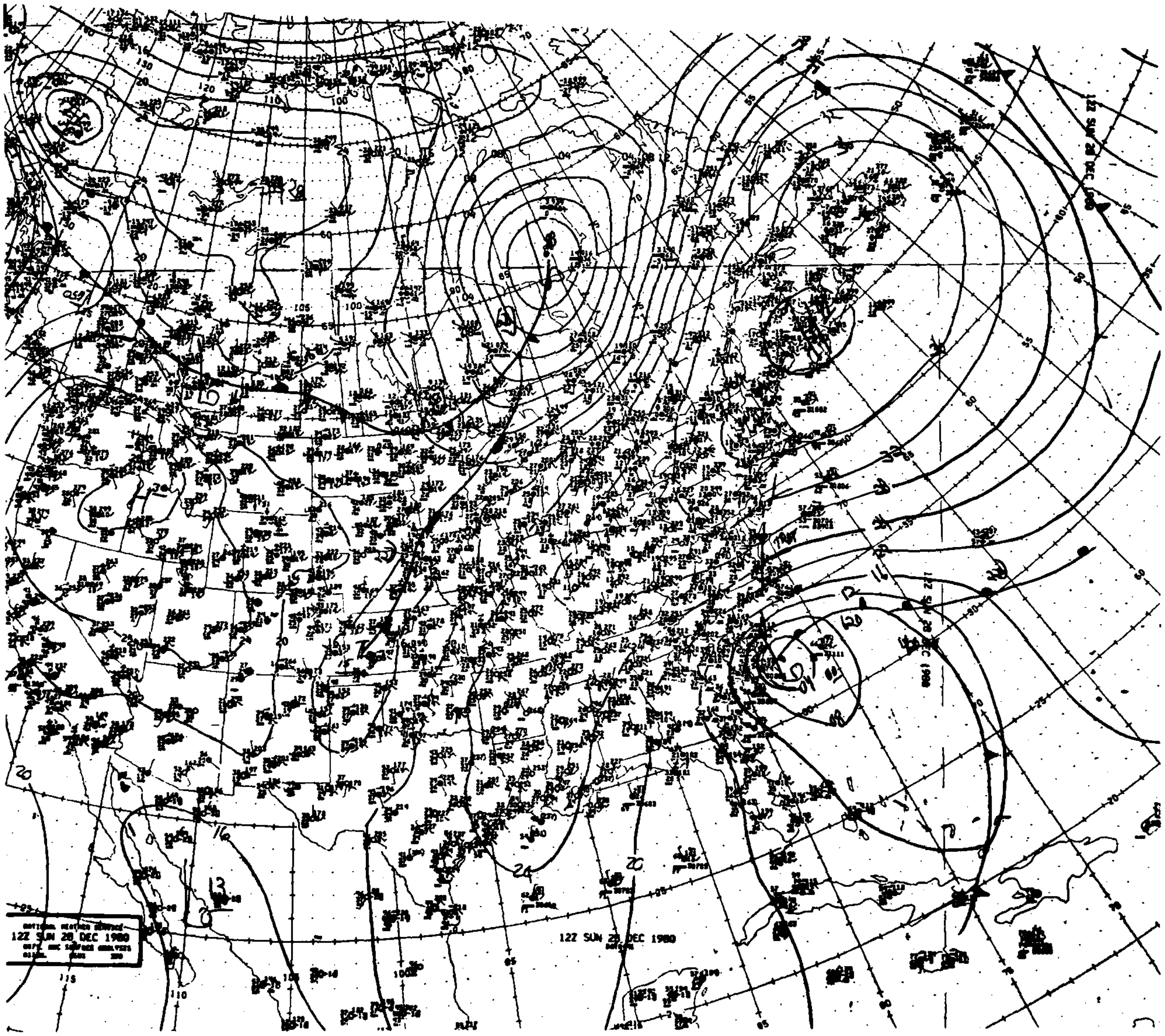

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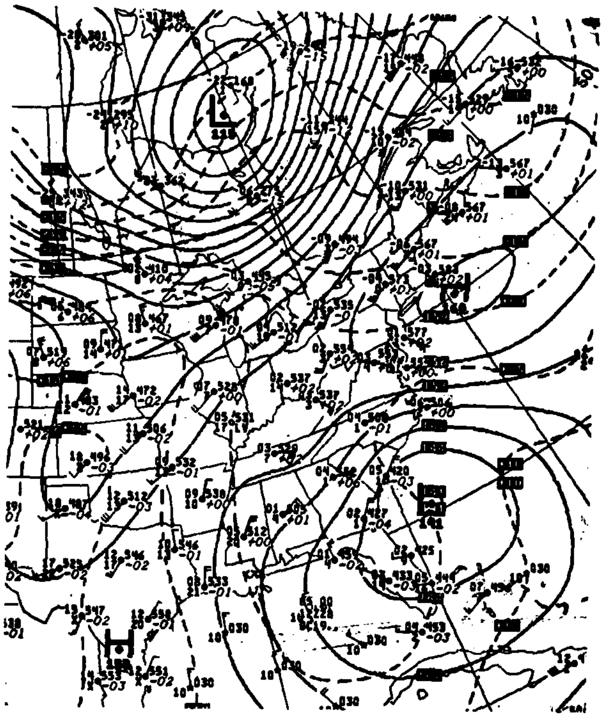

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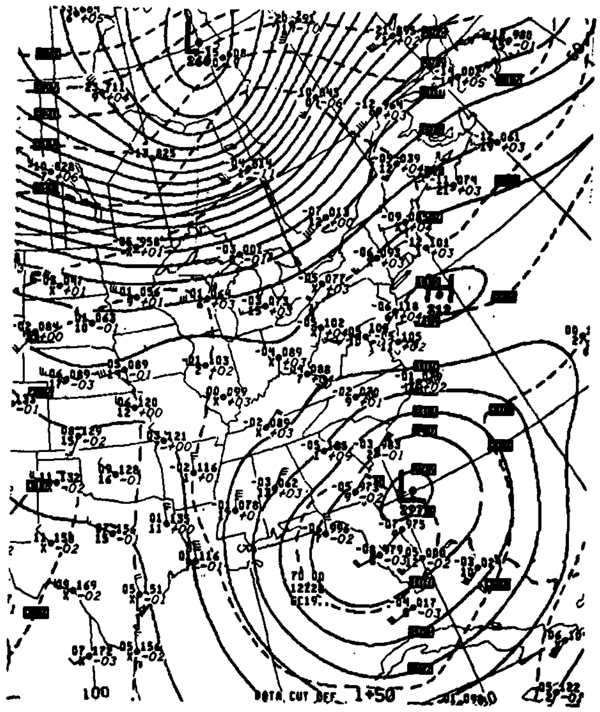

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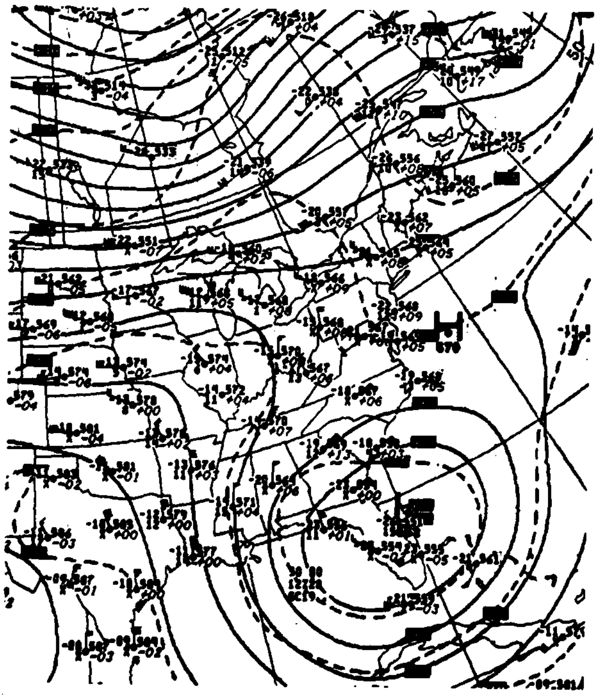

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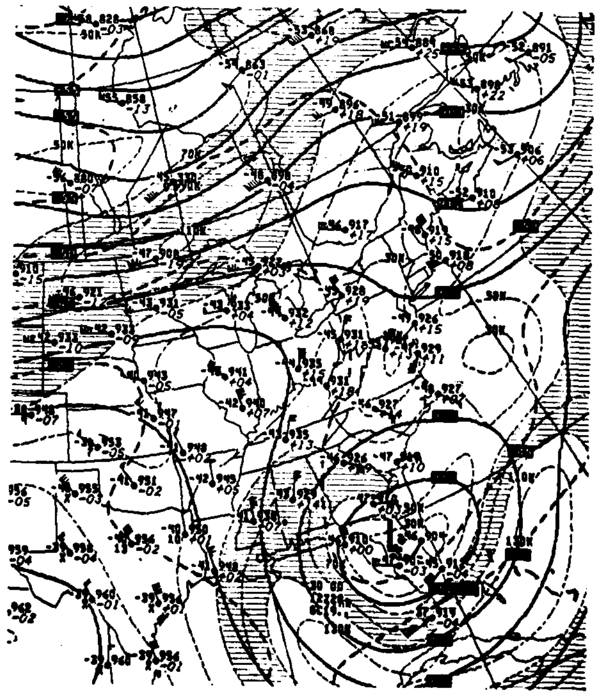

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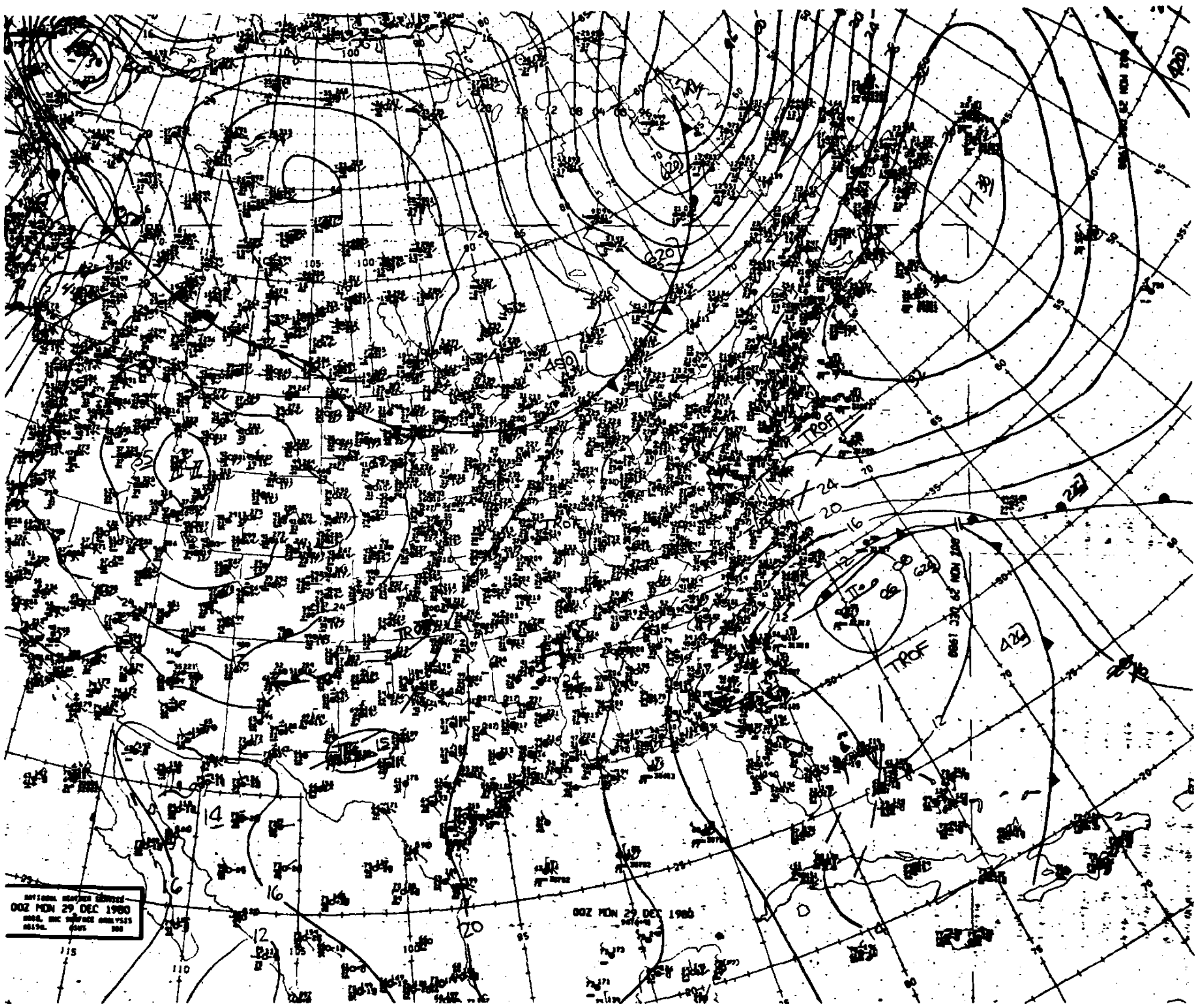
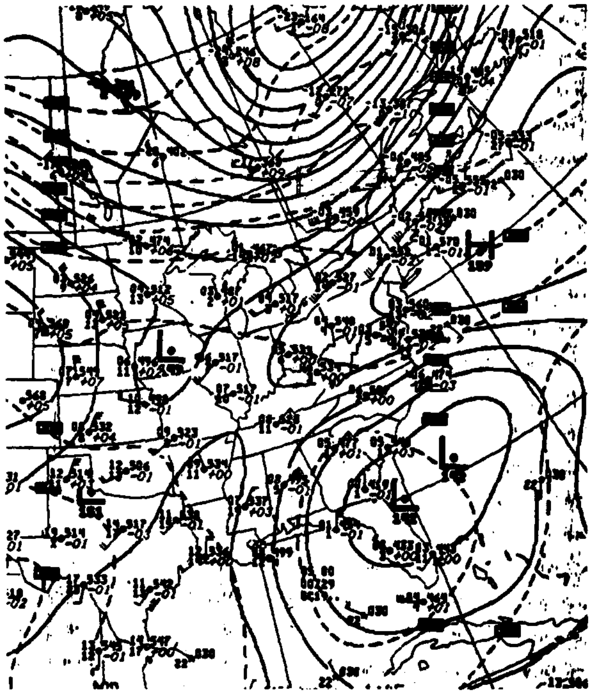


Figure 16. 29/00Z Surface Analysis.



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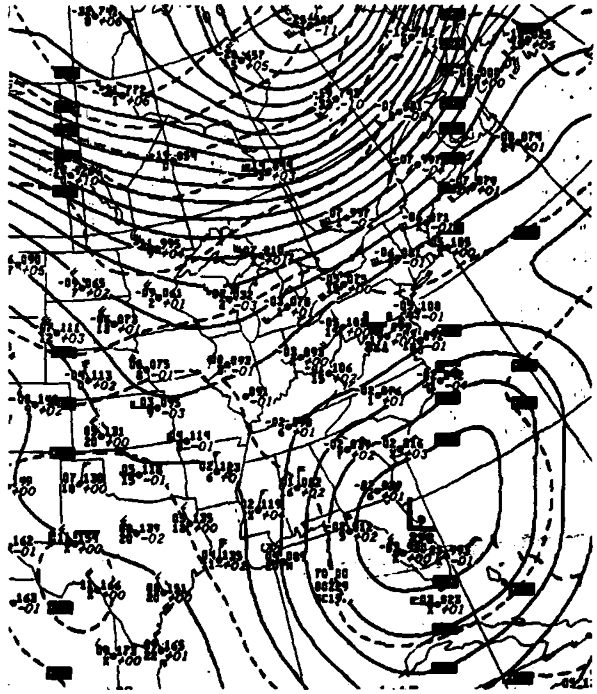

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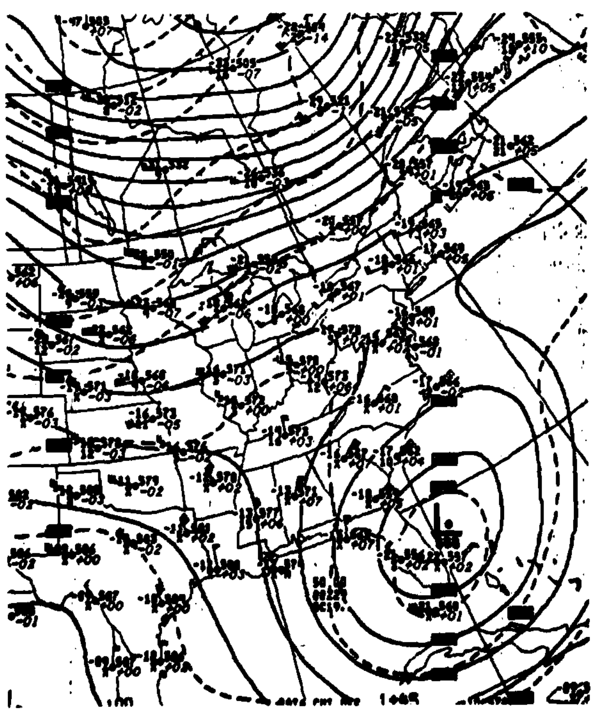

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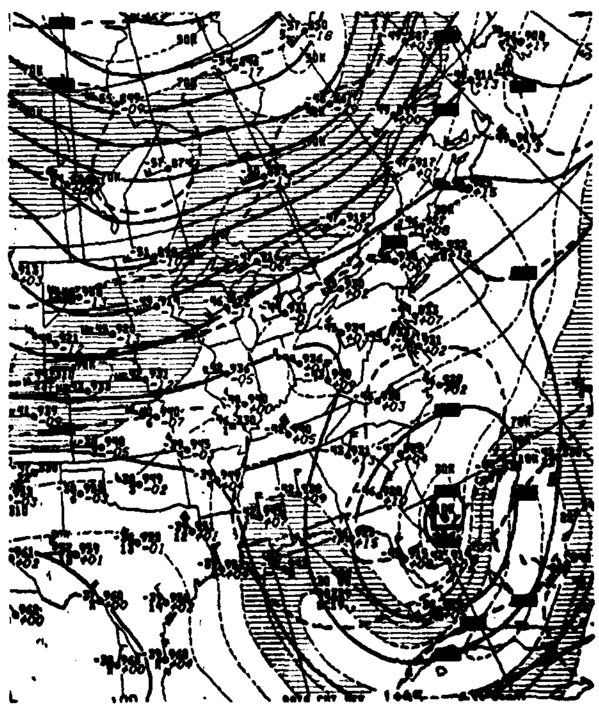

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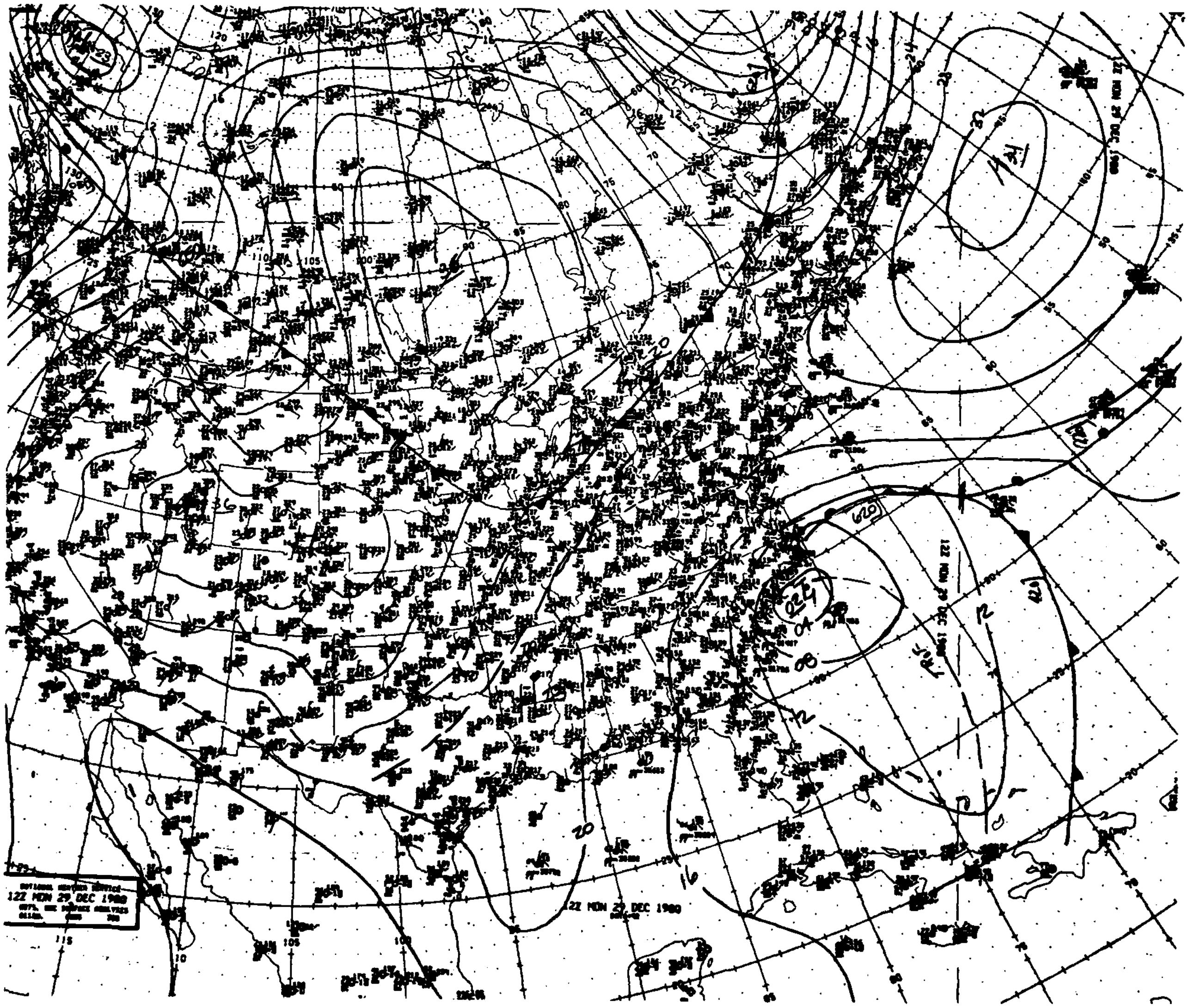

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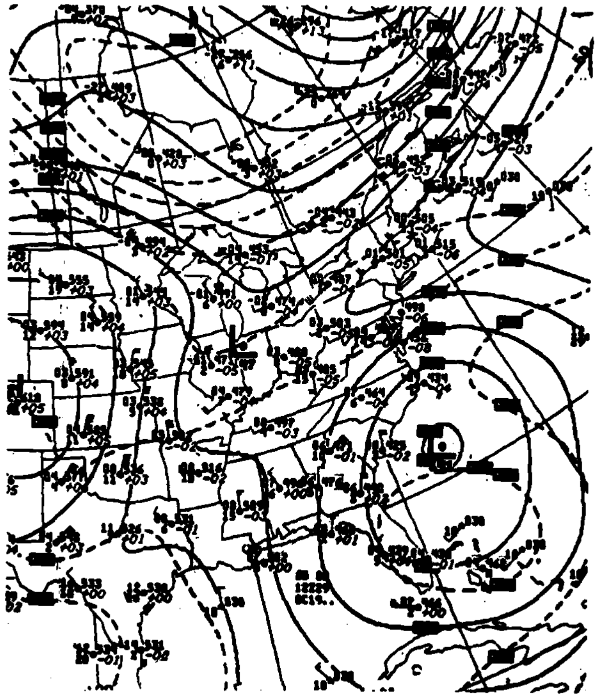

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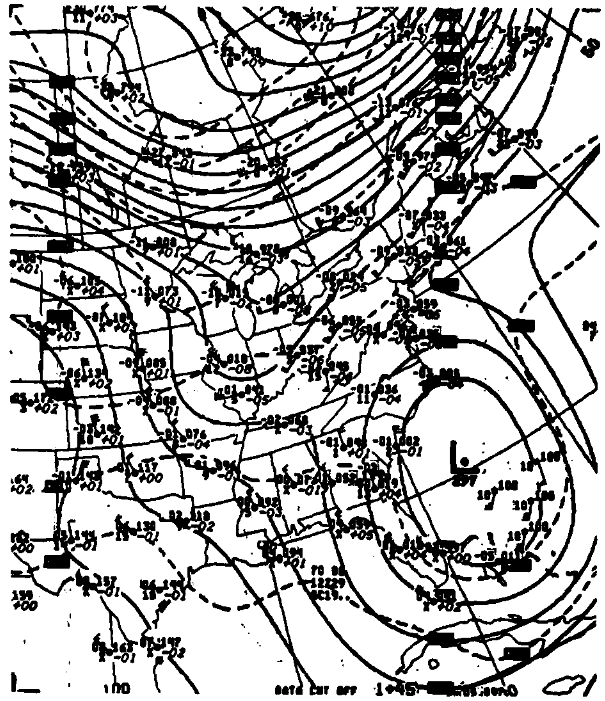

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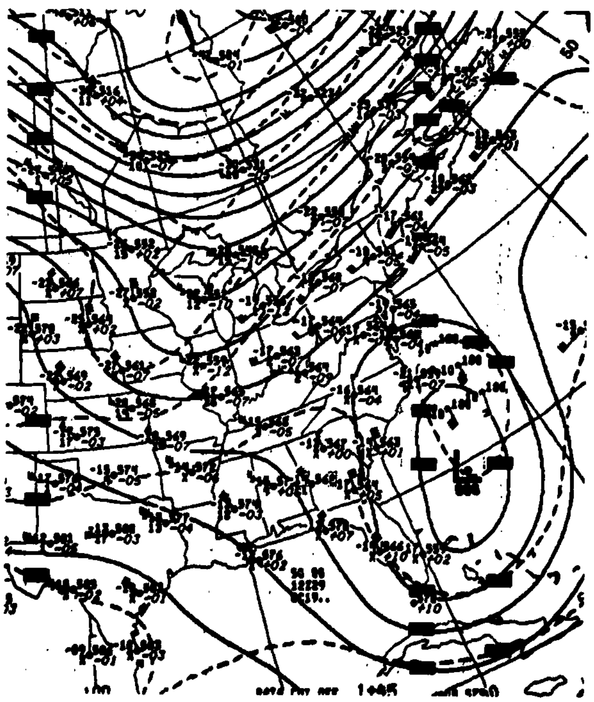

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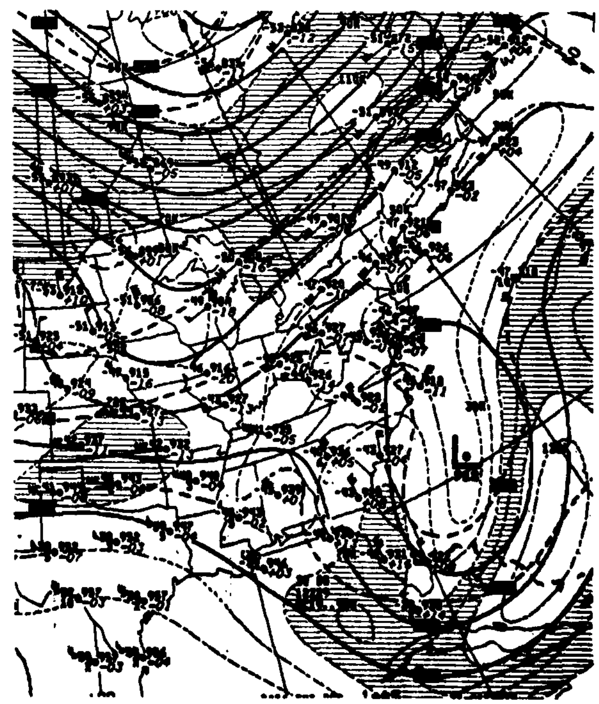

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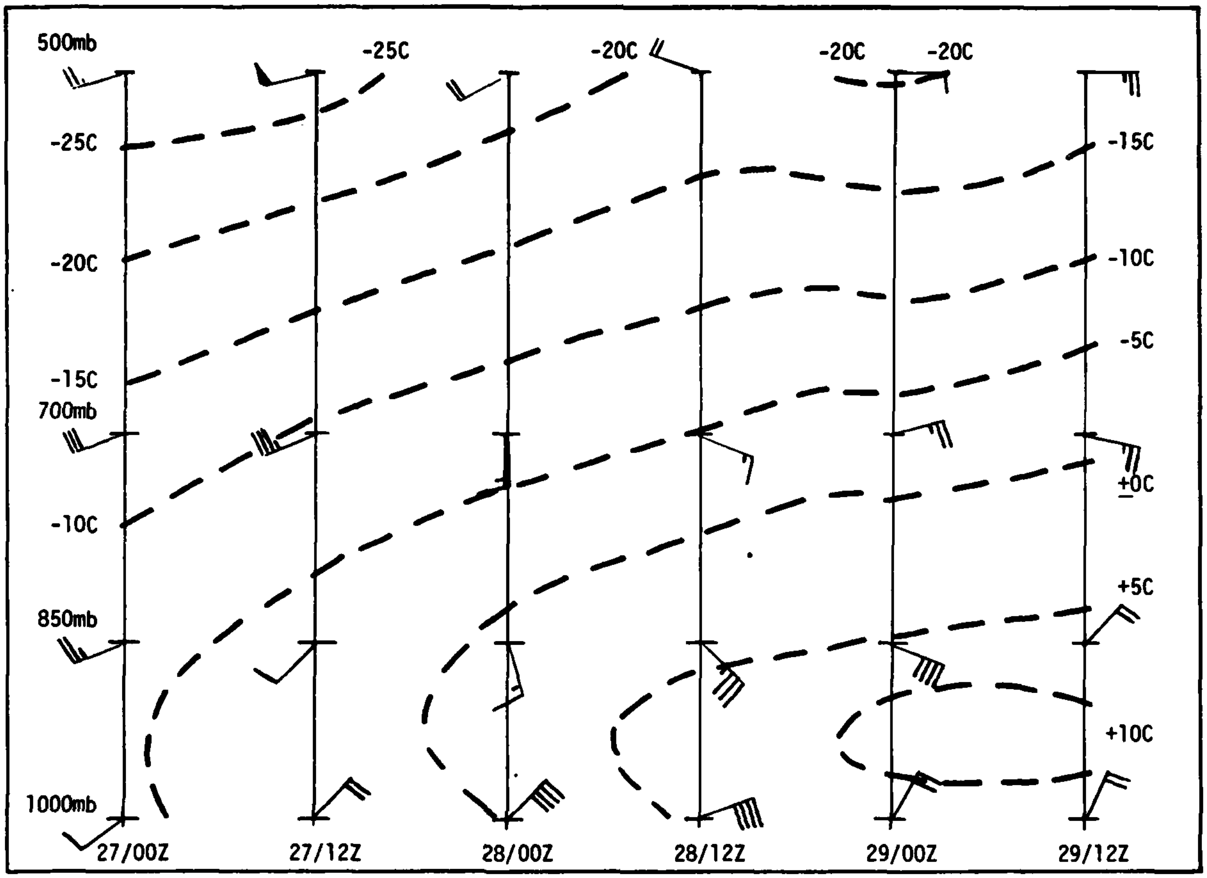

Figure 26. Wallops Island Time Cross-Section, December 1980.

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